Quantification, classification and mapping of spatial uncertainties of floods

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In flood modelling studies, spatial uncertainties may be visualised differently. This will rely on the characteristics of the information produced from the quantification method applied, which may vary depending on the type of model uncertainty taken into account. It is important to be able to characterise and generally classify the different types of spatial uncertainty information in hydraulic model results, because this can help determine how they can be best represented and visualised.

In this paper, two methods of quantifying uncertainties were employed to derive uncertainty information. The first was ensemble-based modelling, which combined the results of 100 simulations considering the effects of the Digital Elevation Model (DEM) and Manning's roughness coefficient to the model output. Each result from the individual model run was assessed on how likely it depicted the spatial extent of an observed flood event. Afterwards, the results were weighted and aggregated. In the second method, the most optimal output based on a series of calibrations from one-dimensional flood modelling was used and applied with the empirical disparity-distance equation to account for further errors brought about by the resolution of the underlying DEM and the slope. The equation was implemented with an algorithm that created uncertainty zones based on the 95% prediction confidence. The resulting information from the two quantification methods were then classified, discretised and visualised using different map types, visual variables, and overlay techniques.

Based on these results, four types of uncertainty information for flood modelling were produced that can be classified according to the characteristics of the data they show: (1) diverging, which is distinguished by two opposing conditions (certain to be dry and flooded) and a middle condition (highly uncertain); (2) sequential, where values range from lowest (uncertain) to highest (certain); (3) multiple calibration results, which show simultaneously the flood extents produced using different parameters for comparative purposes; and, (4) inundation zones which identify areas that are both certain and uncertain to be flooded.

The results from both diverging and sequential uncertainty information were presented as continuous and discrete data in choropleth and graduated symbol maps. The gradation from uncertain-to-certain conditions was displayed using lightest-to-darkest colour and/or smallest-to-largest point symbols. With certainty/uncertainty zone, the binary statuses were represented in choropleth maps as: (a) blue/red colours; (b) organised/disorganised arrangements; and, (c) fine/coarse grain textures. For multiple calibration results, isopleths maps were used with a com-

bination of at least two visual variables (size, shape, colour) to emphasise the differences in the lines, and facilitate visual comparison of results.

Furthermore, since giving geographic context to flood uncertainty is an important aspect in the visualisation, three types of overlay were considered: map pairs, sequential and bivariate representations. Sequential representation worked well for all map types. Bivariate maps, on the other hand, were best for uncertainty represented as [one-coloured] symbol, texture, arrangement and linear features, which do not obscure the information behind. The background map had also to be displayed with increased transparency to prevent its dominance over the uncertainty data. Map pairs were the most suitable for choropleth maps using fill colour in order to avoid problems caused by colour blending when two maps are overlain.

Classification of the uncertainty information facilitated the choice of data representation. Even when using other quantification methods, hydraulic modellers can adopt the suggested visualisation using similar characteristic data. This can be an initial step in producing guidelines for flood uncertainty visualisation. Moreover, testing the effectiveness of these visualisations can be the next relevant step to see how the information is communicated, interpreted and used, e.g. in spatial planning, flood risk management and insurance policies.

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